Using a Guideline-Centered Approach for the Design of a Clinical Decision Support System

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Abstract. Knowledge acquisition for the design of clinical decision support systems can be facilitated when clinical practice guidelines serve as a knowledge source. We have applied the Guideline Elements Model (GEM) in the design of a decision support system to promote smoking cessation. Following markup of knowledge components with the GEM Cutter editor, the Extractor stylesheet was used to create a list of decision variables and actions for further processing, including consolidation and atomization. Removing the critical concepts from the narrative text facilitates clarification of necessary content.

Introduction

The process of creating knowledge-based clinical decision support systems (CDSS) is highly complex. Knowledge—representing best current scientific understanding integrated with the experience of experts—must be acquired and represented in a format that can be processed by computers. Ultimately, software tools must be designed and built to integrate the guideline knowledge into systems of care.

We believe the knowledge acquisition process can be facilitated when current knowledge about best practices can be extracted from clinical practice guidelines that have been created using rigorous, evidence-based methods,. Advantages of making the guideline document a direct knowledge source include preserving the authenticity of the knowledge and the auditability of changes, and potentially diminishing variability in the product. In addition, when translation to a standardized format occurs, there is a potential for knowledge reuse in a multitude of ways.

Several groups have proposed XML-based guideline knowledge representations for CDSS development [1-5]. The Guideline Elements Model (GEM) is an XML representation for practice guidelines [6] that has been standardized as E2210-02 by ASTM International. GEM is a hierarchy of more than 100 elements that can be used to comprehensively classify guideline content. It has been used for guideline quality appraisal [7], partial generation of Medical Logic Modules [8], and guideline implementation [9, 10]

This paper will describe some of the knowledge acquisition tasks in CDSS design and show how an XSL stylesheet can facilitate processing of concepts relevant to guideline implementation.

Smoking Cessation

Cigarette smoking is the most common cause of preventable death and disease in the United States [11]. Smoking cessation can dramatically reduce the risk of lung cancer and other diseases [12]. It has been demonstrated that people who smoke are more likely to quit if their physicians counsel them using evidence-based guidelines on the treatment of tobacco use and dependence [13, 14]. Unfortunately, physicians identify only about half of current smokers, advise fewer than half of them , and assist an even smaller proportion [15, 16].

Using GEM and a document-centric approach (based on the United States Public Health Service guidelines issued in June 2000) [13], we are developing a standalone CDSS for tobacco cessation counseling in primary care offices. Considerable work has already been performed in understanding the perceived needs and preferences of primary care practitioners and clinic administrators to define the desired functionality of the system [17].

Knowledge acquisition process

We view guideline-based CDSS development as a 2-part process. In the first part, relevant guidelines are selected and guideline knowledge is translated into machine usable form. Using GEM, markup provides the initial translation of guideline content into processable text. In the second part of the process, meta-information not supplied by the guideline—but necessary for implementation—is added.

We began design of a CDSS for smoking cessation by examining carefully the guideline document. In print format, the guideline occupies well over 100 pages; however, the information directly relevant to in-office smoking cessation practice was primarily confined to a single chapter, and occupied less than 10% of the text. We have found similar results when looking at other apparently daunting guidelines, i.e., that relevant material is relatively concise.

We proceeded to mark up the relevant material using the GEM Cutter XML editor. This software tool facilitates classification of guideline text into the GEM hierarchy. The bulk of information relevant to decision support design relates to GEM's knowledge components subtree. Much of the GEM hierarchy relating to information about the developer and development process did not require tagging.

In GEM, knowledge components are used to classify definitional material, algorithmic information and guideline recommendations. Each element in the knowledge components tree can be present from 0 to many times. GEM classifies recommendations as either imperative or conditional. Imperative recommendations apply to the entire eligible population. Conditionals, on the other hand, restrict the population by describing conditions that must be satisfied for the recommendation to

be carried out. Conditionals can generally be massaged into statements of the form IF {decision variable(s)) THEN {action(s)).

The GEMified guideline was submitted to Extractor, an XSLT stylesheet application that extracts all decision variables and actions from the surrounding verbiage and formats them in a list. Disassociated from context, that list can be used for many purposes, including atomization of concepts, disambiguation, adjustment of the level of abstraction, and testing for comprehensiveness. In addition, the origins of decision variables and insertion points for guideline-recommended actions can be defined. Implementers can address any deficiencies in these realms early in the CDSS design phase.

Decision Variable	Decision Variable ID
Current tobacco user	DV1
Willing to make a quit attempt	DV2
Those smoking fewer than 10 cigarettes/day	DV3
Pregnant or breastfeeding woment	DV4
Adolescent smoker	DV5
Patient preference	DV6
Previous patient experience with a specified pharmacotherapy	DV7
History of depression	DV8
Patients particularly concerned about weight gain	DV9
Patients for whom first-line medications are not helpful	DV10
History of cardiovascular disease	DV11
Willing to participate in an intensive treatment	DV12
Patient who has quit tobacco use recently	DV13
Never used tobacco	DV14
Abstinent for an extended period	DV15
Adult smoker	DV16

Table 1. Early extract of decision variables from Smoking Cessation guideline.

Consolidation of the list of decision variables facilitates the implementation process. Careful review of the table of raw decision variables indicates that some are closely related. For example, DV5 and DV16 relate to an undefined variable —*smoker's age*—which can take on categorical values of *adolescent* and *adult*. Likewise, a concept common to decision variables 1, 13, 14, and 15 is *tobacco use,* with potential values of *current*, *never used*, *quit recently*, and *abstinent for an extended period*.

Action	Action ID
Ask the patient if he or she uses tobacco	A1
Advise him or her to quit	A2
Assess willingness to make a quit attempt	A3
Prescribe second-line agents clonidine and nortriptyline	A4
Provide a motivational intervention	A5
Reinforce the patient's decision to quit	A6
Special consideration should be given before using pharmacotherapy with selected populations	A7
All five of the FDA-approved pharmacotherapies for smoking cessation are recommended, including bupropion SR, nictotine gum, nicotine inhaler, nicotine nasal spray, and the nictotine patch.	A8

Table 2. Partial extract of actions called for by Smoking Cessation guideline.

Actions (Figure 2) can be augmented with meta-information necessary to place them in canonical form (Figure 3). Actions should be stated in active voice, ideally using transitive verbs. Direct and indirect objects should be instantiated. The "Why" column can often be filled with information extracted from the GEM <reason> element. Actions can be classified into one of the types described by Essaihi (test, monitor, conclude, prescribe, perform, therapeutic procedure, refer/consult, document, educate/counsel, dispose, prepare, or advocate) to facilitate implementation [18].

Who	Action	What	Whom	How	When	Why
Clinician	Prescribe	Nicotine gum	Highly dependent smokers	4 mg (OTC) Chewing instructions in package	Visit (plan phase)	4 mg dose is more efficacious than 2 mg gum
Clinician	Counsel	To quit	Every patient who smokes	In a clear, strong, personalized manner	Visit (History plan)	Physician advice increases abstinence rates

Table 3. Canonical format for stating actions.

Discussion

We describe early steps in the design of a clinical decision support system to facilitate smoking cessation. Using the Guideline Elements Model, the guideline document serves as an authentic knowledge resource whose content can be extracted using a markup process. That markup must be iteratively refined and augmented with external meta-information in order to create a workflow-integrated CDSS.

We have found that extracting decision variables and actions from the contextual narrative facilitates clarification of necessary content. We have used the Extractor XSL stylesheet to perform this task. In other work, we have found that feeding back the Extractor-derived list of decision variables and actions to guideline development teams can improve the decidability and executability of the guideline document.

The origin of extracted decision variables in clinical encounters can be established and used in CDSS design as can the appropriate insertion point of extracted actions. Classification of guideline actions can suggest associated beneficial services that will enhance the usability of the decision support system.

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